Upgrades to the Operational Monte Carlo Wind Speed Probability Program

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USWRP
Joint Hurricane Testbed

Outline

- Joint Hurricane Testbed Project, 2013-2015
- Overview of Monte Carlo Wind Speed Probability Program
- Algorithm Improvements
  - Motivation, methodology, impacts
  - Operational decisions – balancing the impacts
- Product Additions / Enhancements

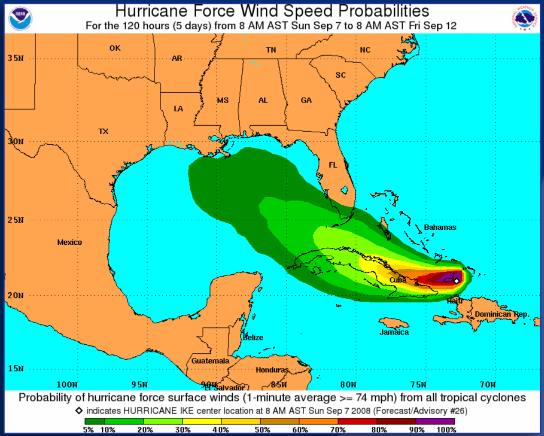
The Monte Carlo Wind Speed Probability Program

- MC Model Basics
  - Estimates probability of 34-, 50- and 64-kt wind to 5 days
  - 1000 track realizations generated from random sampling NHC track and intensity error distributions
  - Wind radii of realizations from radii CLIPER model and its radii error distributions
  - Serial correlation of errors included
  - Probability at a point computed by counting the number of realizations passing within the wind radii of interest

- Developed under Joint Hurricane Testbed (JHT) support
  - Implemented at NHC for 2006 hurricane season
  - Replaced Hurricane Strike Probabilities

- Improvements under JHT support
  - Inclusion of Goerss Predicted Consensus Error (GPCE)
  - Hurricane Landfall Probability Application (HuLPA)
  - Other minor corrections

- ***Experience & NHC feedback led to current project***



Example of 64-kt Wind Speed Probabilities for Hurricane Ike 2008. http://www.nhc.noaa.gov

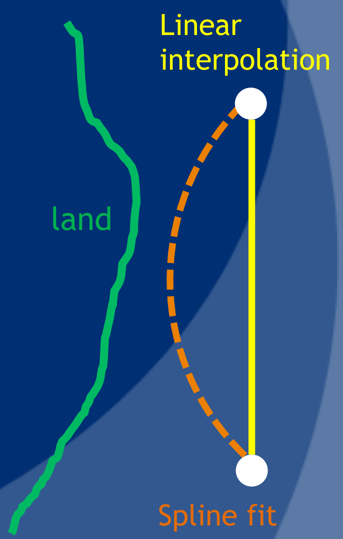
3 Improvements to the MC model algorithm

(2013 – 2015 JHT Project)

- Motivation
- Methodology
- Impacts

Improve time interpolation scheme

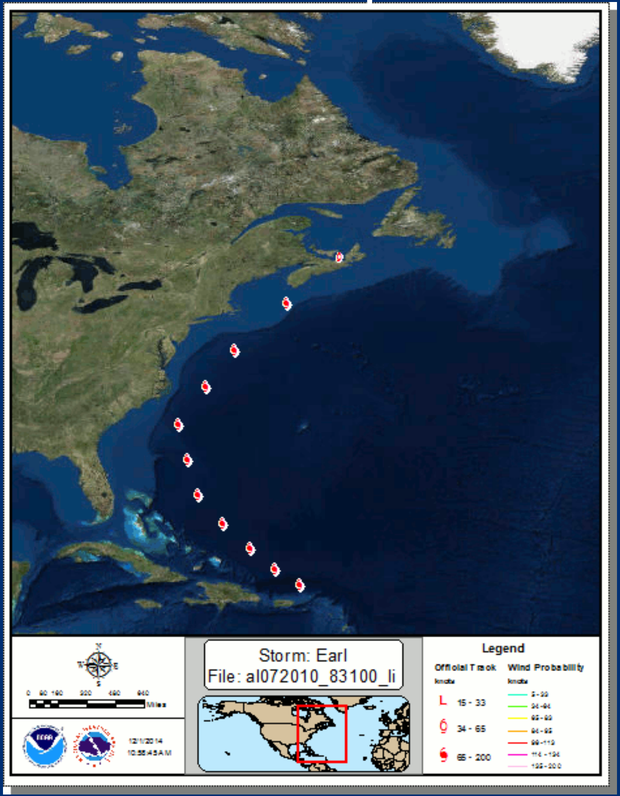
- Motivation
  - MC model needs track forecast at higher temporal resolution than operational forecasts
  - Linear interpolation between time steps introduces track errors
    - Slight eastward bias for recurving TCs
    - Typically on the order of ±1-5% (can be 20-30%)
- Methodology
  - Replaced linear interpolation with spline fit



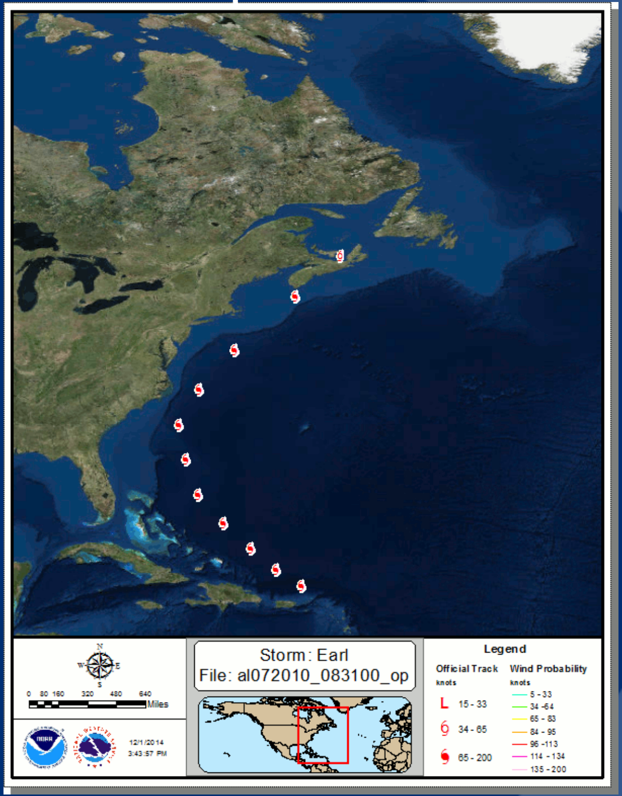
Impacts – spline fit

Smoother, more realistic looking realization tracks

Linear Interpolation



Spline Fit

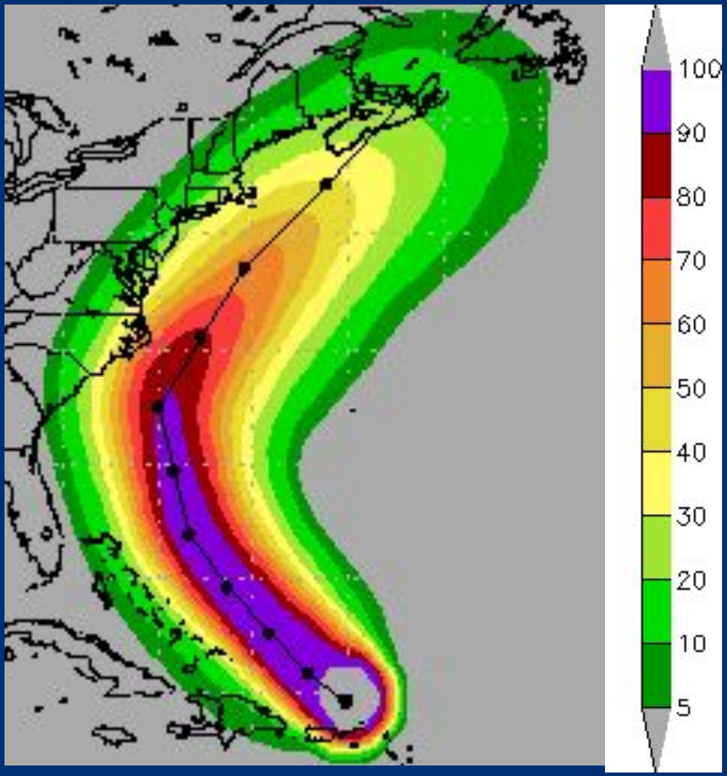


Earl on 31 Aug 2010 at 0Z – using linear interpolation (left) vs. spline (right).
Images courtesy of C. Ogden, NHC.

Impacts – spline fit

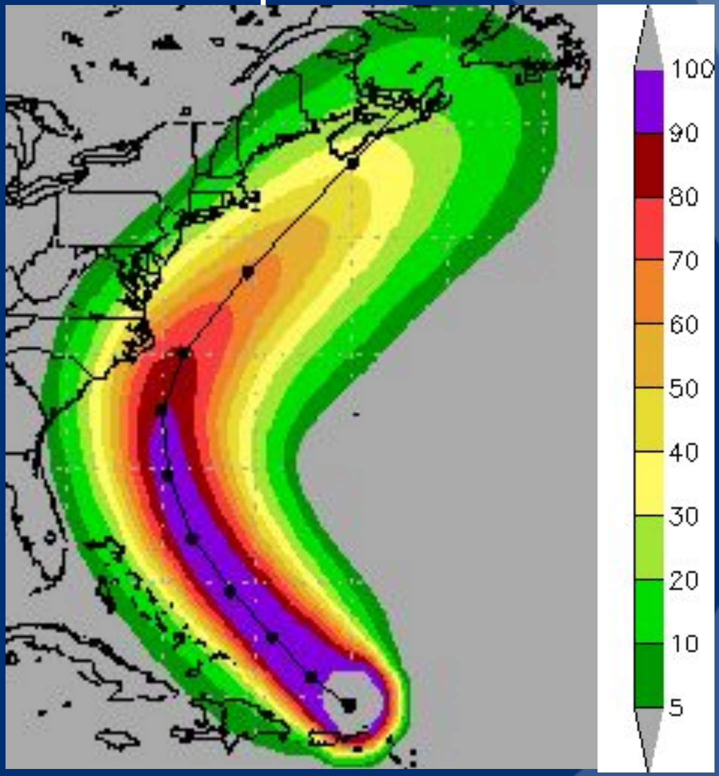
Higher probabilities along coast for recurving tropical cyclones

Linear



Along NC coast, highest probabilities ~ 50-60%

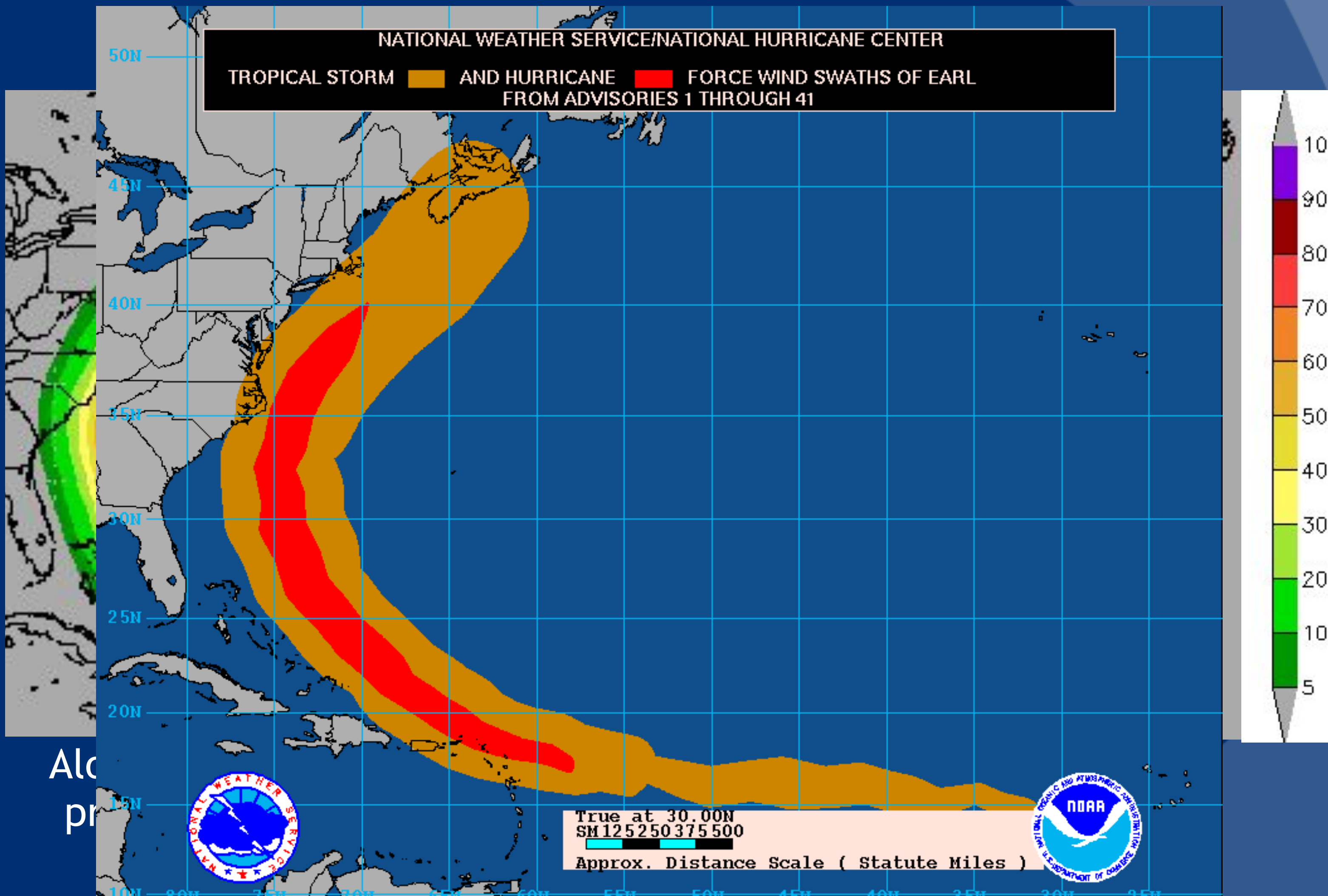
Spline Fit



Along NC coast, highest probabilities ~ 70-80%

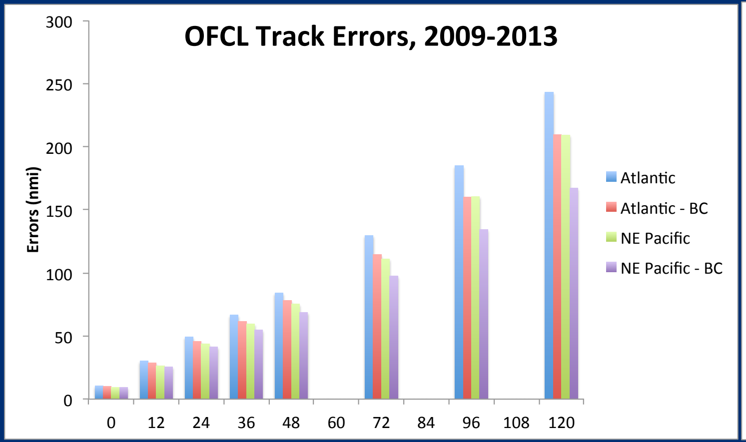
Impacts – spline fit

Higher probabilities along coast for recurving tropical cyclones

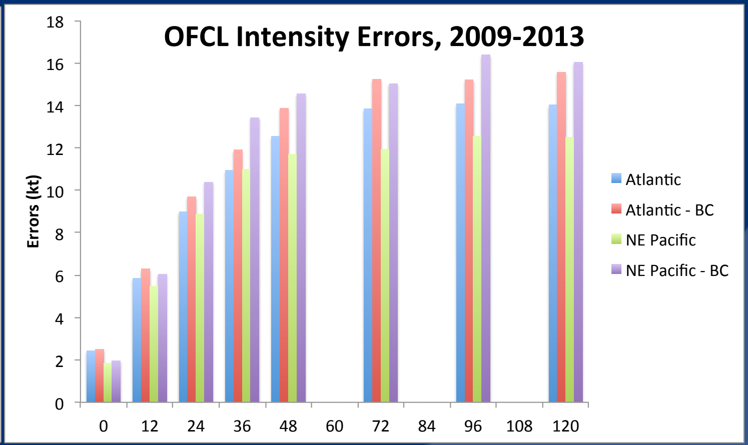


Standardize error statistics

- Motivation
  - Error statistics used to develop wind speed probabilities are slightly different than the official NHC errors - include non-tropical systems (extratropical, post-tropical)
- Methodology
  - Updated MC model error statistics to match NHC errors statistics
- Impacts
  - Improve consistency between NHC uncertainty products



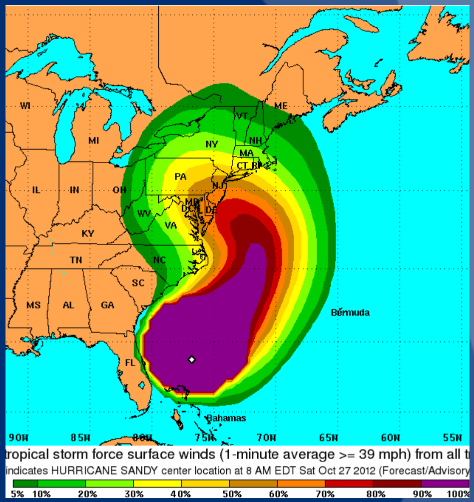
Track errors were too large



Intensity errors were too small

Radii bias correction

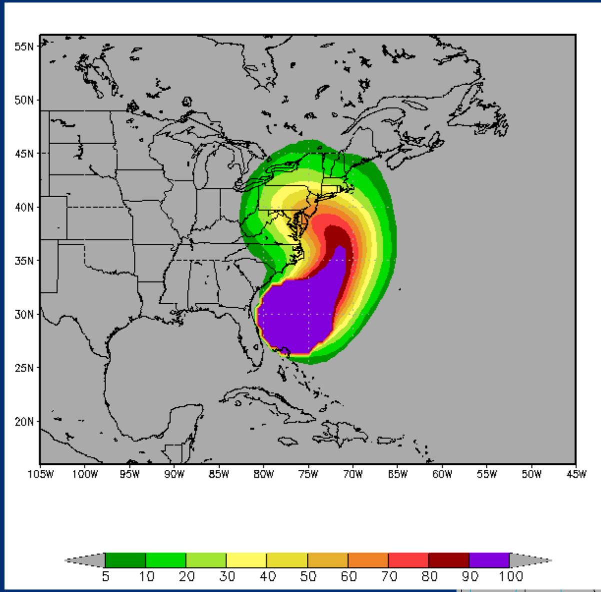
- Motivation
  - MC model uses radii-CLIPER (climatology and persistence) model to estimate wind radii
    - Contribution of persistence has e-folding time of 32 hours (DeMaria et al. 2009)
    - For TCs much smaller (larger) than climatology, radii-CLIPER potentially overestimates (underestimates) radii for t > 32 hours
- Methodology
  - Bias Correction (BC) = (OFCL radius forecast) – (ensemble mean)
  - BC added to all realization radii
  - When official radius forecast not available, use last available BC weighted by time to last forecast (e-folding time ~36 hours)



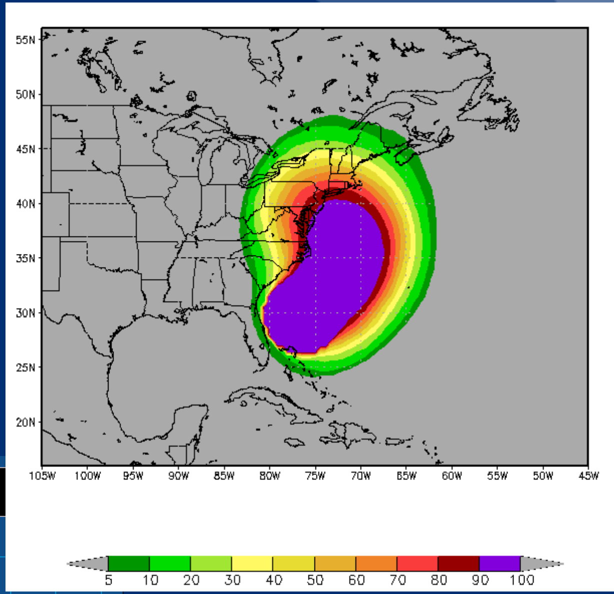
E.g., Hurricane Sandy, 10/27/12 12Z

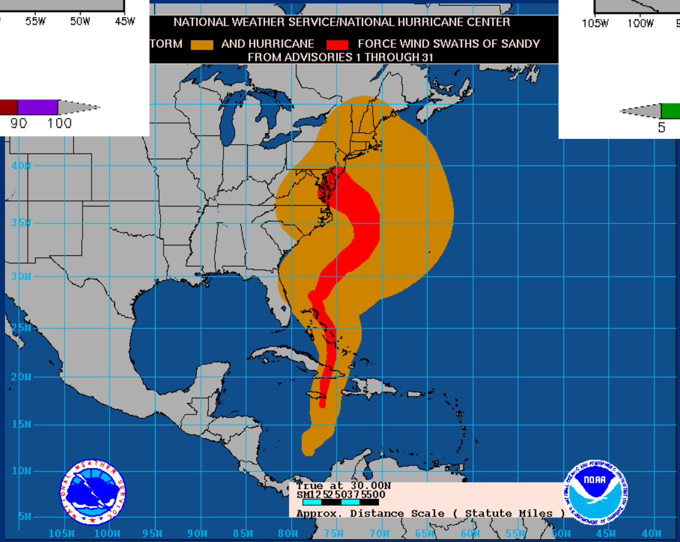
Impacts – radii bias correction

Current Algorithm



Radii bias correction

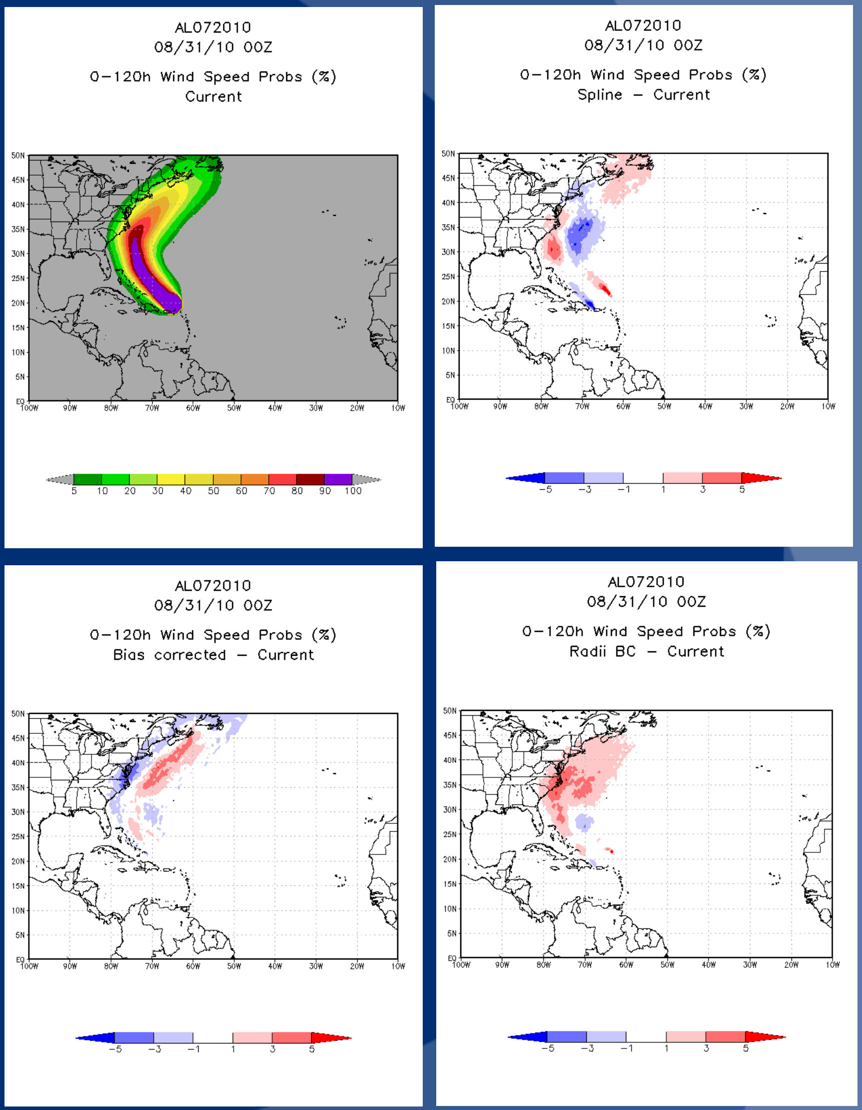




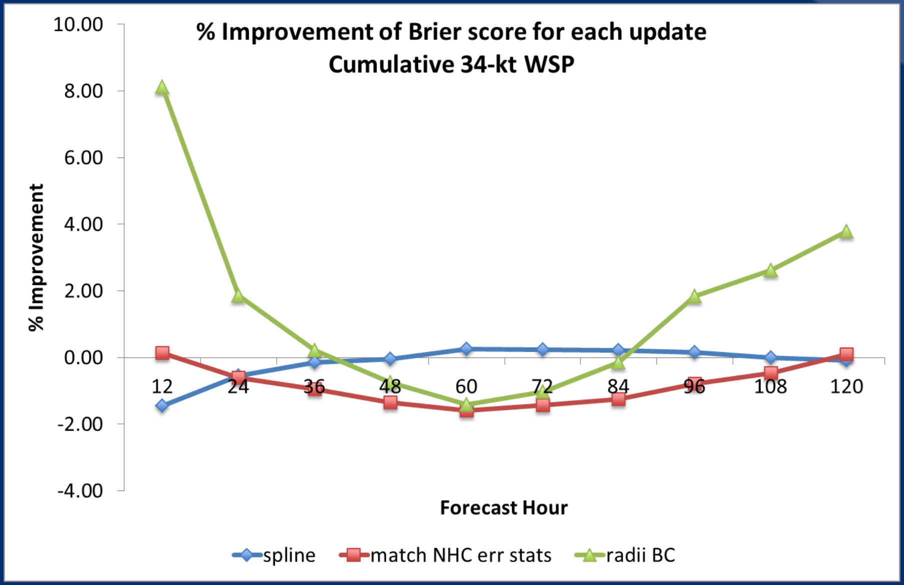
Sandy, 10/27/12 12Z

Evaluating the updates

- Cases (already shown)
- Real-time display for monitoring
  - Parallel runs at CIRA
  - Each update displayed separately
  - Difference plots (example →)
- Quantitative evaluation
  - Use Best Track position, intensity, and radii estimates as ground truth
  - Compute Brier scores and biases for each update individually
  - 3-year sample (2011-2013)



Quantitative evaluation of each update

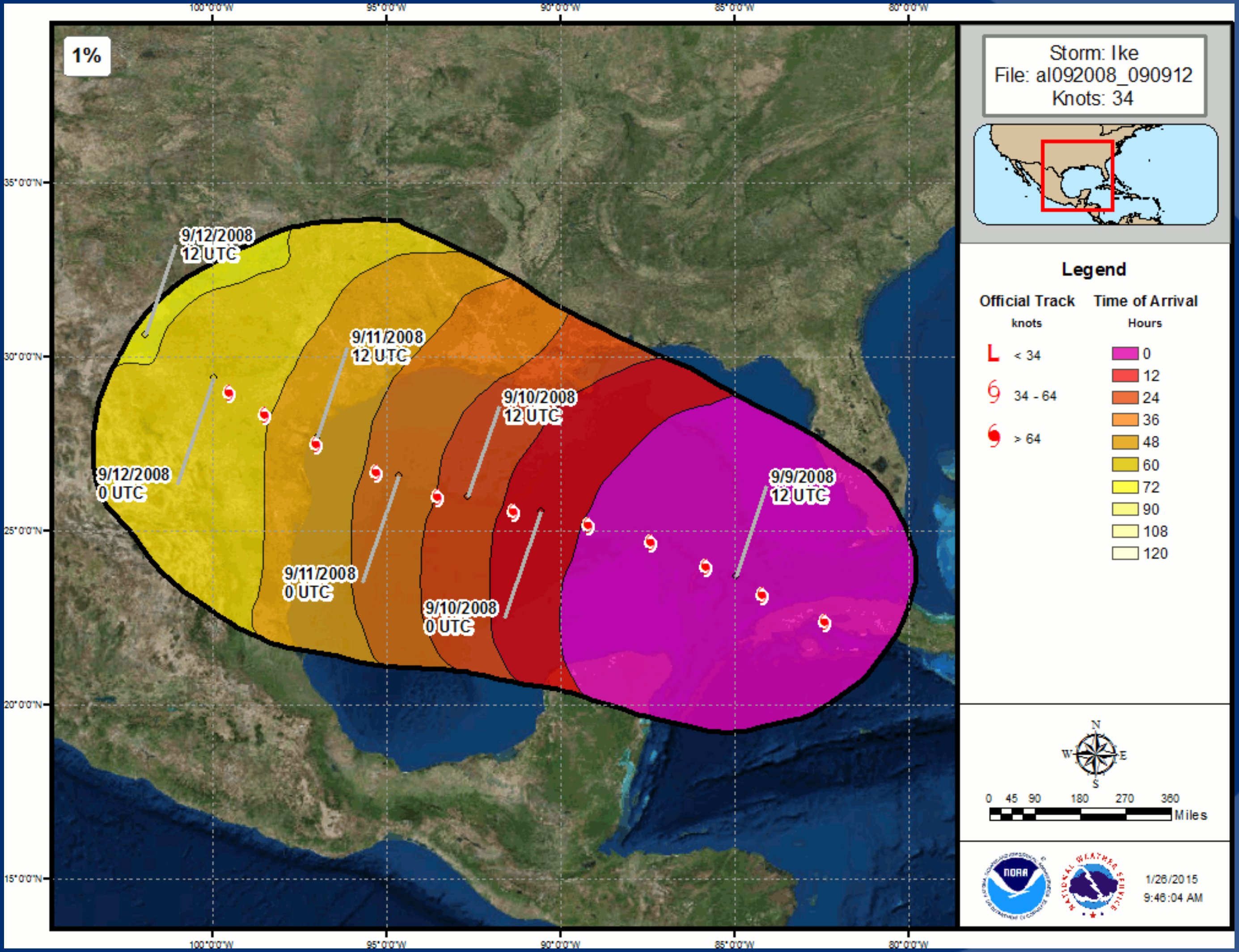


- Balancing impacts
  - Spline fit realization tracks look more realistic, may provide substantial improvement for recurving cases along U.S. coast
  - Updating error statistics provides consistency among NHC's uncertainty products, potential future application of MC model in generating dynamic cone of uncertainty
  - Radii bias correction positive impact on cases where TC is much smaller or larger than climatology
- Ultimately, JHT/NHC has final say on updates accepted into operations

Getting MORE out of the MC model

- Extending wind speed probabilities to 7 days
  - Currently only available out to 5 days
  - Experimental, “in-house” 6 and 7 day forecasts
- Integrated GPCE parameter
  - GPCE = Goerss predicted consensus error
  - Currently used in MC model to adjust wind speed probabilities based on expected forecast uncertainty
  - Bring this uncertainty information out of model, provide to forecasters directly
- Time of arrival & departure estimates of 34, 50, and 64-knot winds
  - Based on arrival/departure times of realizations
  - Threshold can be customized based on risk tolerance (e.g., 10th, 50th, 90th, 99th percentiles can be used)
  - Complex, iterative evaluation process between developers, forecasters, social scientists

Time of arrival estimates



Summary

- MC model is a highly-used public product developed within the JHT
- JHT continues to support improvements & additions to the MC model
  - Innovation through forecaster exposure and experience
  - Recent project supports 3 improvements, 3 additions, and a software upgrade
- Success in the JHT directly related to effective communication between developers, forecasters, and users
  - Iterative process of R2O2R (or is it R2O2U2O2R2…?)
  - Operations (NHC) has final say

Thank you!

- Acknowledgments
  - Research supported by the Joint Hurricane Testbed (USWRP)
  - National Hurricane Center points of contact: M. DeMaria, C. Landsea, M. Brennan, D. Brown, C. Mattocks
  - Additional National Hurricane Center support: R. Berg, C. Ogden

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